

1 **BACKGROUND OF THE INVENTION**

2 **1. Field of the Invention**

3 The present invention relates to a method for performing resistance-type
4 exercises and, more particularly, to a method and devices operable for changing
5 the direction and magnitude of a resistive force in a cyclic manner multiple times
6 during a single repetition of muscular contracture.

7 **2. Prior Art**

8 Resistance exercise devices are well known in the art. Resistance exercises
9 normally involve the contraction of a muscle against an opposing resistive force
10 to move a portion of the body through a range of motion. The contraction is
11 usually repeated to include a plurality of cycles (repetitions) of motion of the body
12 portion through the range of motion, which range is determined by the degree of
13 muscular contraction and extension achieved during a repetition. The resistive
14 force may be provided by gravity, as with weight training (barbells, dumbbells,
15 pull-up and pull-down stacks of weights, etc.), or by an elastic force such as
16 springs, bungees and the like.

17 Weight lifting is an exercise in which muscles are contracted against a
18 resistance that is moved through a range of motion. The resistance is normally in
19 the form of a weighted object that the user moves through either a flexion or
20 extension of a body portion such as the arms or legs. In weight lifting, there are a
21 number of exercises in which the user moves a weighted barbell in order to

1 strengthen his or her upper body muscles. One example of such an exercise is a
2 bench press in which the individual initially assumes a supine position atop a
3 support bench. The weightlifter then uses his or her arms to lift the barbell from a
4 position just above the lifter's chest to a higher vertical position where the lifter's
5 arms are fully extended. This exercise is normally accomplished without any
6 sideways movement (abduction or adduction) of the lifter's hands. This basic
7 exercise can be modified by inclining the support bench (inclined press) or by
8 starting with the bar substantially coplanar with the user's torso (pull overs).

9 In the biomechanics of limb function, there one or more joints which
10 contribute to the limbs functional motion. Each time the limb moves, motion takes
11 place in one or more of these joints. Limb movement, such as movement of the
12 arm, may include flexion, extension, abduction, adduction, circumduction,
13 internal rotation, and external rotation. These movements are usually defined in
14 relation to the body as a whole. Flexion of the shoulder is a forward movement of
15 the arm. Extension, the reverse of this, is backward movement of the arm.
16 Abduction is the movement of raising the arm laterally away from the body;
17 adduction, the opposite of this, is then bringing the arm toward the side.
18 Circumduction is a combination of all four of the above defined movements, so
19 that the hand describes a circle. Internal rotation is a rotation of the arm about its
20 long axis, so that the usual anterior surface is turned inward toward the body;
21 external rotation is the opposite of this.

1 All movements of limbs, for example, the arm relative to the shoulder, can
2 be described by the terms used above. It will be appreciated by the artisan that
3 most movements of a limb such as the arm are combinations of two or more of the
4 above defined movements. A plurality of muscles cross each limb joint. Their
5 function is to create motion, and thus the ability to do work with the limb. To
6 perform a given task with precision, power, endurance, and coordination, most, if
7 not all, of these muscles must be well conditioned.

8 The function of each of these limb muscles depends on its relative position
9 to the joint axis it crosses, the motion being attempted, and any external forces
10 acting to resist or enhance motion of the limb. During limb motion, groups of
11 muscles interact so that a desired movement can be accomplished. The interaction
12 of muscles may take many different forms so that a muscle serves in a number of
13 different capacities, depending on movement. At different times a muscle may
14 function as a prime mover, antagonist, or a fixator or synergistically as a helper, a
15 neutralizer or a stabilizer.

16 For example, consider flexion of the arm. There are three major joints
17 which contribute to elbow function: the ulnar-humeral, radio-humeral, and the
18 radio-ulnar. The ulnar-humeral is responsible for flexion and extension while the
19 radio-humeral and the radio-ulnar joints are responsible for supination and
20 pronation. Flexion is movement in the anterior direction from the position of
21 straight elbow, zero degrees to a fully bent position such as a curl. Extension is

1 movement in a posterior direction from the fully bent position to the position of a
2 straight elbow.

3 A plurality of muscles effect motion at each limb joint. For example, in the
4 elbow, these include the Biceps brachii, the Brachialis and the Triceps brachii.

5 These muscles are continually active as their role changes in performing the
6 complex activities of daily living. Each muscle spanning a limb joint has a unique
7 function depending on the motion being attempted. It is generally conceded that in
8 order to fully train and strengthen limb musculature, it is necessary to work the
9 limb in all planes and extremes of motion to optimize neuromuscular balance and
10 coordination.

11 The types of limb exercise and/or exercise devices currently used in
12 exercise programs generally include isometric, isotonic and isokinetic exercise.

13 Isometrics is an exercise that is performed without any joint motion taking place.
14 For example, pressing a hand against an immovable object such as a wall. When
15 exercising a muscle group within a limb, strength can be improved only in the
16 range of motion in which the limb is being exercised. Since in isometric exercises
17 only one position and one angle can be used at one time, isometric exercise is
18 time consuming if done correctly.

19 Isotonic exercises are done against a movable resisting force. The resisting
20 force is usually free weights. Isotonic exercises are probably the most common
21 method for exercising both the the upper and lower limbs as free weights are

1 relatively inexpensive to acquire and readily available in gyms. A weight is held
2 in the hand and moved in opposition to gravity. It is a functional advantage to be
3 able to move a limb through a full range of motion, but because of the
4 unidirectional nature of gravity, the body position must be continually changed
5 for all muscles to be exercised.

6 During a single repetition of isotonic weightlifting, the load remains
7 constant but the amount of stress on the muscle varies. The most difficult point in
8 the range is the initial few degrees with a movement to overcome inertia. As the
9 upper extremity comes closer to the vertical position, work becomes easier due to
10 improved leverage. This creates a noncyclic variability in the degree of muscle
11 tension throughout the range of motion. Isotonic exercises can be performed on
12 Nautilus and similar machines which achieve a more uniform resistance. A major
13 disadvantage is that motion on these weightlifting machines is confined to a
14 straight plane movement without deviation which does not replicate normal in-use
15 movement of the limb.

16 Isokinetic exercise involves a constant speed and a variable resistance.
17 Isokinetic exercise machines are currently limited to movement of a limb in one
18 straight plane. The advantage of exercising a limb with an isokinetic device is that
19 the resistive force can be bi-directional within the single plane of movement.
20 Current isokinetic machines do not permit motion of the limb through different
21 planes during a single repetition.

1 The particular muscle fibers involved in a contraction during a single
2 repetition of resistive exercise depends upon the direction of the resistive force
3 vector. If the resistive force vector is constant during a repetition, both
4 directionally and in magnitude, as is the case with most prior art resistance
5 exercise devices, only the muscles and portions of the muscle fibers within a
6 muscle that are necessary to counter the resistive force will contract. Push-
7 down/press-down (“PD2”) types of exercise devices, such as, for example,
8 disclosed in U.S. Patent Application Publication Number US2002/0068666 by
9 Brucolieri, have been further improved to include flexible members attached to a
10 horizontal resistance bar. The flexible members are adapted to be grasped by the
11 hands. In operation, the direction of the resistive force vector changes during a
12 repetition such that different muscles and different muscle fibers within a muscle
13 are exercised during the repetition. While the direction of the resistive force vector
14 at the point of contact with the exercisor’s body (i.e., the hands) changes during a
15 repetition using PD2-type devices, the magnitude of the resistive force does not
16 exhibit oscillations during a repetition. The prior art pull-down/press-down
17 resistance type of exercise devices, such as the device shown in Figure 1, enable
18 the user to exercise a plurality of muscles during a repetition because the plane of
19 motion of the limbs varies during a repetition and it enables a full range of motion
20 of the limb through a repetition. A disadvantage for this type of device is that the

1 vertical component of the resistive force F_2 (Figure 1) is constant during a
2 repetition.

3 It is desirable to provide a resistance exercise device wherein the direction
4 of the resistive force oscillates in a cyclic fashion during a single repetition in
5 order to increase the number of muscle fibers involved in the contraction over the
6 number required when using a unidirectional device. There is also a need for a
7 resistance exercise device wherein the magnitude of the resistive force oscillates
8 over a plurality of cycles during a single repetition.

9 **SUMMARY**

10 It is an object of the present invention to provide a resistance exercise
11 device operable for providing resistance to the movement of a muscle wherein the
12 magnitude of the resistance oscillates for a plurality of cycles during contraction
13 of the muscle that occurs while performing a single repetition.

14 It is a further object of the present invention to provide a resistance
15 exercise device operable for providing resistance to the movement of a muscle
16 wherein the direction of the resistance oscillates for a plurality of cycles during
17 contraction of the muscle while performing a single repetition.

18 It is yet a further object of the present invention to provide a resistance
19 exercise device operable for providing resistance to the movement of a muscle
20 wherein both the direction and the magnitude of the resistance oscillates for a
21 plurality of cycles during contraction of the muscle.

1 The features of the invention believed to be novel are set forth with
2 particularity in the appended claims. However the invention itself, both as to
3 organization and method of operation, together with further objects and
4 advantages thereof may be best understood by reference to the following
5 description taken in conjunction with the accompanying drawings.

6

7 **BRIEF DESCRIPTION OF THE DRAWINGS**

8 Figure 1 is a perspective view showing the movable portions of a pull-
9 down/press-down type of exercise device in accordance with the prior art.

10 Figure 2 illustrates the resistive force vector provided by a prior art pull-
11 down/press-down type of exercise device and the contractile force vectors applied
12 by an exercisor that is required to overcome the resistive force vector.

13 Figures 3a-e are graphic representations illustrating examples of some of
14 the possible oscillations in the magnitude F_2 and/or the direction Φ of the
15 resistive force vector during a single repetition in accordance with the present
16 method. The range of motion during the repetition begins on the left and
17 terminates on the right.

18 Figure 4 is an elevational side view of an angular oscillation lead pulley in
19 accordance with a preferred embodiment of an exercise device of the present
20 invention. The angular oscillation lead pulley is used to cyclically change the

1 direction of the resistive force vector F2 a plurality of times during the
2 performance of a single repetition of exercise.

3 Figure 5 is an elevational side view of an angular oscillation lead pulley in
4 accordance with another preferred embodiment of an exercise device of the
5 present invention. The angular oscillation lead pulley is used to cyclically change
6 the direction of the resistive force vector F2 nonuniformly and half as frequently
7 during the performance of a single repetition of exercise than the lead pullet
8 shown in Figure 4.

9 Figure 6 is an elevational view of a “bowtie” lead pulley in accordance
10 with a second preferred embodiment of an exercise device of the present
11 invention. The bowtie lead pulley simultaneously changes the leverage and thus
12 the magnitude of F2 and the angular displacement Φ of the resistive force vector
13 in an oscillatory manner during the performance of a single repetition.

14 Figure 7 is a schematic diagram of a pull-down/press-down device in
15 accordance with an embodiment of the present invention employing a cam-like
16 lead pulley having a smaller circumference than the preceding cam-like pulley
17 wherein the magnitude of the resistive force F3 oscillates throughout the range of
18 motion R during a repetition of the exercise.

19 Figure 8 is a graphical representation showing the change in the resistive
20 force F3 throughout the range of motion R for the embodiment of the invention
21 illustrated in Figure 7.

Figure 9 is a front view of a lead pulley suitable for use with a PD2-type of exercise device to cause the direction of the resistive force to oscillate wherein the plane of the lead pulley is tilted with respect to its axis of rotation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to Figure 1, a pull-down/press-down (PD2) device in accordance with the prior art is indicated in perspective view at numeral 10. For simplicity, only the moving parts of the PD2 device 10 are shown. In the device 10, a weight stack 11 is in mechanical connection to a handgrip 12 by means of a cable 13. The cable has a trailing end 13' attached to the weight stack 11 and a leading end 13'' attached to the handgrip 12. The cable 13 is supported by a rear pulley 14 and a lead pulley 15. The term "lead pulley" as used in the discussion of PD2 devices to follow, refers to the pulley supporting the cable that is closest to the leading end 13'' of the cable 13. The handgrip 12 may be a pair of handles connected to the free end 13'' of the cable by means of ropes or cables as shown, or it may comprise a bar, or similar grasping means.

If the rear pulley 14 has a circular groove 16, the resistive force F_1 (a directional arrow in Figure 1) will be equal to the weight of the weight stack and oriented in the direction of the corresponding arrow. If the lead pulley 15 also has a circular groove 16', the resistive force vector F_2 will be equal to F_1 in magnitude. If the sum of the projections of applied force vectors F_3 and F_3' along

1 the axis defined by F2 is greater than resistive force F2, the weight stack 11 is
2 lifted. When the applied forces F3 and F3' are relaxed, the weight stack returns to
3 its original position until either the applied force F3 and F3' is reapplied, or it
4 comes to rest on a support such as a floor (not shown) when the sum of the
5 projections of F3 and F3' along the axis defined by F2 becomes less than F2.

6 The lead pulley 15 may be modified (Figures 4 and 5) such that when the
7 lead pulley 15 turns as the cable 13 passes thereover, the lead pulley 15 changes
8 the direction of F2 to displace the vector F2 through an angle Φ as shown in
9 Figure 2. Figure 2 illustrates the resistive force vector F2 provided by a prior art
10 pull-down/press-down type of exercise device and the applied force vectors F3
11 and F3' applied by an exercisor that is required to provide a resultant force vector
12 F4 having a magnitude greater than the resistive force vector F2 in a direction
13 opposite to F2. As the direction of F2 changes due to the displacement of the
14 cable through an angle Φ , the projections of F3 and F3', F3v and F3'v, along the
15 axis defined by the shifted direction of F2 will also change. The applied forces F3
16 and F3' must be changed by the exercisor in order to adapt to the fluctuating
17 direction of F2. In order to adapt to the fluctuating (oscillating) direction of F2
18 during a repetition, the exercisor will need to contract more different muscles than
19 are required with a constant F2.

20 The angle of displacement Φ and the magnitude of F2 can be made to
21 oscillate during a repetition. Some examples of the change in magnitude and

1 direction of F2 that are possible with particular lead pulley constructions, as will
2 be discussed below, are shown in Figures 3a-e. Figure 3a illustrates a sinusoidal
3 fluctuation in either the magnitude or direction (or both) of F2 that occur during a
4 single repetition. Figure 3b shows sawtooth fluctuations. Figure 3c illustrates a
5 train of narrow pulses whereas Figure 3d illustrates a square wave. Figure 3e
6 shows a modified sawtooth fluctuation in the magnitude and/or direction of F2
7 during a single repetition.

8 Various means such as mechanical, hydraulic or pneumatic devices may
9 be employed to vary the direction and/or magnitude of the resistive force F2 in an
10 oscillatory manner over a plurality of cycles during a repetition. Mechanical
11 design of the lead pulley is a simple effective means for accomplishing such
12 changes. Figure 4 is an elevational view of an angular oscillation lead pulley 40 in
13 accordance with a preferred embodiment of a PD2 exercise device of the present
14 invention. The angular oscillation lead pulley 40 is used to cyclically change the
15 direction of the resistive force vector F2 a plurality of times during the
16 performance of a single repetition of exercise. This is accomplished by forming
17 the cable groove 16 in a cylindrical member 41 such that as the cylindrical
18 member 41 turns about its axis of rotation A, the uppermost portion 42 of the
19 groove 16, which supports and guides the cable (the cable is not shown in Figure
20 4), travels laterally in an oscillatory manner, returning to its starting position with
21 every complete rotation of the cylindrical member 41. The cylindrical member 41

1 has a diameter D. The pulleys 40, 50 and 60 are all rotatably mounted and
2 supported on the PD2 device by means of a cylindrical axle (not shown) affixed to
3 the cylindrical member 41 coaxially with the axis of rotation A.

4 Figure 5 is an elevational side view of an angular oscillation lead pulley 50
5 in accordance with another preferred embodiment of an exercise device of the
6 present invention. The angular oscillation lead pulley 50 is used to cyclically
7 change the direction of the resistive force vector F2 irregularly and half as
8 frequently during the performance of a single repetition of exercise than the lead
9 pulley 40 shown in Figure 4.

10 The lead pulley designs presented above are suitable for providing a
11 resistive force F2 that oscillates in direction during the performance of an exercise
12 repetition. Figure 6 is an elevational view of a “bowtie” lead pulley in accordance
13 with a second preferred embodiment of an exercise device of the present
14 invention. The bowtie lead pulley 60 has a variable diameter D over the portion of
15 the cylindrical member 41 traversed by the groove 16 and simultaneously changes
16 the leverage and thus the magnitude of F2 and the angular displacement Φ of the
17 resistive force vector in an oscillatory manner during the performance of a single
18 repetition.

19 The frequency of oscillation of the magnitude and/or direction of the
20 resistive force F2 depends upon the particular lead pulley design and the speed at
21 which the lead pulley rotates about the rotational axis A during the performance

1 of a repetition. The number of cycles in the change of direction and/or magnitude
2 in the resistive force F_2 that occurs during a repetition depends on the number of
3 rotations the lead pulley makes during a repetition. It is obvious that for a lead
4 pulley having the groove design illustrated in Figures 4-6, a cylindrical member
5 having a small diameter D will provide more oscillations during a repetition
6 than a lead pulley having a greater diameter D . Accordingly, in accordance with
7 the goal of the present invention, it is desirable to select D such that the lead
8 pulley rotates a plurality of times during a repetition.

9 Figure 7 is a schematic diagram of a pull-down/press-down device 70 in
10 accordance with a double cam-pulley embodiment of the present invention. The
11 device 70 employs a cam-like lead pulley 15 having a smaller circumference than
12 the preceding cam-like pulley 71 wherein the magnitude of the resistive force F_3
13 oscillates throughout the range of motion R during a repetition of the exercise.
14 Figure 8 is a graphical representation showing the change in the resistive force F_3
15 throughout the range of motion R for the embodiment of the invention 70
16 illustrated in Figure 7.

17 With continued reference to the PD2 device 70 of Figure 7, the lead pulley
18 15 may be cam-shaped and orthogonally mounted on its rotational axis 15a as
19 shown or it may be tilted on its rotational axis 15a. If the plane of the lead pulley
20 15 is tilted with respect to its rotational axis 15a, the resistive force F_3 , shown in
21 Figure 8 for an orthogonally mounted lead pulley, it will be appreciated by the

1 artisan that the resistive force F_3 will further have an oscillating component in and
2 out of the plane of the paper (not shown) that is orthogonal to a plane defined by
3 the resistive force vectors F_1 and F_2 . Figure 9 is a front view of a lead pulley
4 suitable for use with a PD2-type of exercise device that is operable for causing the
5 direction of a component of the resistive force to oscillate in and out of the plane
6 of the paper (Figure 7). The plane P of the lead pulley 15 is tilted by an angle θ
7 with respect to its axis of rotation A . In addition to being tilted, the lead pulley 15
8 may also be cam-shaped to provide oscillatory changes in both the direction and
9 the magnitude of the resistive force during a single repetition.

10 The method for performing an exercise using the devices described above
11 requires that the muscle(s) being exercised adapt to a fluctuating resistive force a
12 plurality of times during a repetition. The adaptation requirement provides means
13 for strengthening more cooperating muscles during a repetition than is possible
14 when countering a constant resistive force. The method and device of the present
15 invention enables the noncontiguous innervation of muscles during a repetition. It
16 is noted that the muscles involved in a repetition “learn” how to adapt if the cyclic
17 variations in the resistive force occur synchronously during each repetition. It is,
18 therefore, desirable to design the exercise device such that the rotational
19 orientation of the lead pulley at the beginning of each repetition is different than
20 the orientation of the lead pulley at the beginning of the previous repetition.

1 While particular embodiments of the present invention have been
2 illustrated and described, it would be obvious to those skilled in the art that
3 various other changes and modifications can be made without departing from the
4 spirit and scope of the invention. For example, as mentioned hereinabove, a
5 variety of means such as pneumatic or hydraulic pumps and programmable
6 controllers therefore, as well as specially designed lead pulleys as described
7 hereinabove can be employed to cause the resistive force to oscillate in magnitude
8 and/or direction during a repetition. With the use of programmable computer
9 means, the waveform and/or the frequency of oscillations in the resistive force can
10 also be made to fluctuate either in a predictable pattern or a random fashion during
11 a repetition. Further, although the invention has been presented using a PD2
12 device as an example of a device embodying the principles of the method, other
13 resistance-type exercise devices employing an oscillating resistive force during a
14 repetition are contemplated. It is therefore intended to cover in the appended
15 claims all such changes and modifications that are within the scope of this
16 invention.

17 What I claim is:

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